Real and Virtual pH-meter in Early Chemistry Education

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Introduction

Currently, the real life brings more and more virtual environment items, new virtual worlds etc. The school experiment is to be purposeful, i.e. clear, appropriated to pupils’ age, simple, well organized, visible and safe. The objective of our research project is to discover possibilities and their limits in the use of virtual environment supporting early chemistry education [1]. It means to research effectiveness of the computer simulations and animations applied in early chemistry education (basic school, grades 8 – 9), either independently, or in various combinations with the real experiment. The core of the research is to conclude relations and recommendations for meaningful and effective use of virtual measuring devices realized by computer simulations and animations, remote and virtual laboratories, etc. [2 – 4].

Virtual devices for pH-measurements in Chemistry instruction

The taking (measuring) various quantities conducted or supported by computers is supposed to mean virtual measuring devices, in Chemistry it means physical and physical-chemical figures. Basically, virtual measuring devices are of two types:

1) computer generates the environment for measuring on the screen, and data are collected from the real environment by real meters or sensors and analogue-digital convertors providing the adapted signal for further processing [more in e.g. 5, 6],

2) computer generates both the environment for measuring on the screen, and the appropriate signal, i.e. the measured figures, via mathematical and formal-logical models.

In this paper we deal with the latter situation of so called virtual measuring devices, i.e. computer simulations. The spreading offer of software products for general chemical education related to this area provides examples from the above mentioned T. Greenbowe portal [2], e.g. the simulation of measurements with pH-meter. The pH figure is applied in the topic of "The acidity and alkalinity of solutions", but numerous primary and secondary schools are not equipped with so many pH-meters they need for this experiment. They can use simulated measurements by the virtual pH-meter, which is presented on the web side. Various activities are offered, e.g. pH figures of selected acids, bases, salts and unknown solutions, results can be compared to real measurements by the universal pH-indicator, specify pH figures of unknown matters etc.

The pH measurements and relating acid-basic titrations probably are one of the most frequently used topics in modelling and creating computer simulations. Apart from the pH-meter by T. Greenbowe (figure 1), other examples can be mentioned, e.g. PhET - the
simulator of pH measurements of selected matters from common life which is available at WWW-pages called "Interactive Simulations" of the University of Colorado (figure 2) [7], elements of the virtual reality in the project of the distance on-line education, University of Thessaloniki (figure 3) [8], the chemical laboratory for measurements by potenciometer available at ChemCollective portal [9], or numerous simulations of acid-basic titrations and setting molar concentration of an unknown acid or base [e.g. 10].

Figure 1 Virtual pH-meter by T. Greenbowea on the WWW page of the Chemistry Department, Iowa State University, available at http://www.chem.iastate.edu/group/Greenbowe/sections/projectfolder/flashfiles/acidbasepH/pH_meter.html [2]

Figure 2 Simulator of pF measurements "PhET", available at WWW page "Interactive Simulations", University of Colorado http://phet.colorado.edu/simulations/sims.php?sim=pH_Scale [7]
As seen from the presented examples, the terminology (e.g. virtual laboratory, virtual devices etc.) closely relates to modelling and simulations (applets). A well-known tool for searching them on the Internet is available at the NatSim server ("Natural Science Simulations" [http://www.natsim.net]) [11]. Results of the NatSim-Search provide links for creating a web page with an applet for downloading an applet in the archive or directly executable file.

Research design and the first results

The basic school pupils undergo a pilot research on laboratory pH measuring supported by real and virtual (simulated) device, i.e. a virtual pH-meter, this is an available simulation on T. Greenbowe Web page [2], and a manual pH-meter in the real set on the laboratory desk. Two as much as identical scenarios were prepared using either real or virtual pH-meter, managed by worksheets containing tasks of three levels:

- **Level 1**: simple pH measuring in three samples of selected chemical matters (hydrochloric acid, sodium hydroxide and sodium chloride) in three different strengths.
- **Level 2**: answers to problematic questions followed by their verifying by measuring changes in parameters of the matters (strength, volume, similar chemical matters), e.g. What pH figure will a certain volume of hydrochloric acid solution reach having lower/higher strength than in previous measuring? How will pH sodium hydroxide with strength of 0.06 mol/dm$^3$ change when its volume increases from 100 ml to 150 ml? What pH figure will potassium hydroxide solution reach in comparison to sodium hydroxide solution if the strength is the same? Etc.
- **Level 3**: open task, e.g. Design and describe assignments and results of other tasks which you could do with the provided aids and real or virtual chemicals. You can ask your teacher to provide you with other chemicals and aids for the real experiment, or with advice on other functions of the simulated pH-meter for the virtual experiment.

Both versions of the laboratory practice have run at a basic school. Two groups of pupils participated in the empiric research, and the method of pedagogical experiment with crossing the sample groups was applied. Group B showed a lower level of motivation for learning Chemistry, so this group started with the virtual experiment, and the real one followed. Group
A, the group with better evaluation, i.e. with better marks in Chemistry, ran the real experiment first. The difference in knowledge after both types of experiments monitored by a didactic test was not statistically significant. It could be caused by the combination of both environments (real/virtual, virtual/real). During the observations of the laboratory practice we noticed the real activities developed a closer relation between pupils and matters in the surrounding world, pupils connected Chemistry with real life in a wider extent. Virtual activities do not build such a relation, the matters to be measured were given before, and pupil’s activities were bounded by the computer environment. Having finished both types of activities, pupils expressed their opinion in a questionnaire evaluating their work in the real and virtual environment. According to the responses in the questionnaire pupils were divided into two groups: those who strongly prefer real measurements, and the others. Correlation between opinions and results in the didactic test proved, the group preferring real measurements had reached better results (the difference is statistically significant) in the didactic test. These are interesting findings which will be consequently verified by the relevant number of respondents at basic schools and eight-year grammar schools.

**Conclusion**

As indicated in the previous text, the computer and other information technologies can be used as helpful supportive means emphasizing methodological aspects of the natural science instruction. According to [1], it mainly means the support of experimenting and modelling, of managing the setting of empiric and theoretical hypotheses and forming the empiric or theoretical piece of knowledge. Thus the objective of the ICT implementation is to optimize educational conditions, i.e. to support planning, projecting, running and evaluation of instruction, so that the pre-defined educational objectives were reached efficiently. We are trying to contribute to meaningful use of the combination (blend) of the real and virtual environment in the natural science instruction, which may become one of the crucial preconditions of innovation in the field of school experimental activities [1].

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**LITERATURE**


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